

Kuldeep Purohit

Image Processing and Computer Vision lab
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RESEARCH INTEREST

Broad Areas: Image Processing, Computer Vision and Deep Learning.
Working on : Restoration of images and videos suffering from blur, low-resolution, and haze and their utilization for scene segmentation and estimation of 3D geometry and motion.

EDUCATION

Indian Institute of Technology Madras, Chennai, India January 2014 - present
MS+PhD in Image Processing and Computer Vision
Guide: Prof. A.N.Rajagopalan

Indian Institute of Technology Mandi, Himachal Pradesh, India 2009 - 2013
Bachelor of Technology in Electrical Engineering

WORK EXPERIENCE

Research Intern December 2016 - May 2017
KLA-Tencor Corporation.
E-Beam Wafer Inspection Team

Research Assistant January 2014 - Present
Indian Institute of Technology Madras, Chennai, India.
Department of Electrical Engineering

Intern December 2011 - January 2012
Center for Artificial Intelligence and Robotics, Defense Research and Development Organization, India
Computer Vision Group

Project Assistant May 2012 - June 2012
National Institute of Technology Bhopal, India.

PUBLICATIONS

1. *Kuldeep Purohit*, Anshul B. Shah, and A.N. Rajagopalan, "Bringing Alive Blurred Moments," In International Conference on Computer Vision and Pattern Recognition (**CVPR**), 2019.(Accepted)
2. *Kuldeep Purohit*, Srimanta Mandal, and A.N. Rajagopalan, "Mixed-Dense Connection Networks for Image and Video Super-Resolution," In **Neurocomputing**, 2019. (Accepted)
3. *Kuldeep Purohit*, Srimanta Mandal, and A.N. Rajagopalan, "Scale-Recurrent Multi-residual Dense Network for Image Super-Resolution," In the European Conference on Computer Vision (**ECCV**) Workshop on Perceptual Image Restoration and Manipulation, 2018.
4. Srimanta Mandal, *Kuldeep Purohit*, A.N. Rajagopalan, "Color Image Super Resolution in Real Noise," In ACM Indian Conference on Computer Vision, Graphics and Image Processing (**ICVGIP**), December 2018.
5. *Kuldeep Purohit*, Anshul B. Shah, and A.N. Rajagopalan, "Learning based Blur Detection and Segmentation," In International Conference on Image Processing (**ICIP**), September 2018.

6. *Kuldeep Purohit*, Subeesh Vasu, A.N. Rajagopalan, Bala Naga Jyothi and Raju Ramesh, "Color Image Super Resolution in Real Noise," In ACM Indian Conference on Computer Vision, Graphics and Image Processing (**ICVGIP**), December 2016.
7. *Kuldeep Purohit* and A.N. Rajagopalan, "Splicing Localization in Motion Blurred 3D Scenes," In International Conference on Image Processing (**ICIP**), September 2016.

Manuscripts Under Review

1. *Kuldeep Purohit*, Srimanta Mandal, and A.N. Rajagopalan, "Multi-level Weighted Enhancement for Underwater Image Dehazing," to Journal of the Optical Society of America A (**JOSA-A**), 2019.
2. *Kuldeep Purohit* and A.N. Rajagopalan, "Efficient Motion Deblurring with Feature Transformation and Spatial Attention," to International Conference on Image Processing (**ICIP**), 2019.

RESEARCH PROJECTS

Learning based sharp Video Extraction from a Single Blurred Image

IIT

Madras

Designed a deep convolutional architecture to extract a sharp video from a motion blurred image. The first stage involves unsupervised training of a novel spatio-temporal network for motion extraction from short video sequences. The above network is utilized for guided training of a CNN which extracts the same motion embedding from a single blurred image. The above networks are finally linked with our efficient deblurring network to generate the sharp video. Our framework delivers state-of-the-art accuracy in single image deblurring and video extraction, while being faster and more compact.

Mixed-Dense Connection Networks for Image and Video Super-Resolution

IIT

Madras

Proposed a deep architecture for image and video super-resolution, which is built using efficient convolutional units we refer to as mixed-dense connection blocks, whose design combines the strengths of both residual and dense connection strategies, while overcoming their limitations. We enable efficient super-resolution for higher scale-factors through our scale-recurrent framework which reutilizes the filters learnt for lower scale factors recursively for higher factors. We analyze the effects of loss configurations and demonstrate their utility in enhancing complementary image qualities. The proposed networks lead to state-of-the-art results on image and video super-resolution benchmarks.

Color Image Super Resolution in Real Noise

IIT Madras

Proposed an approach to super-resolve noisy color images by considering the color channels jointly. Implicit low-rank structure of visual data is enforced via nuclear norm minimization in association with color channel-dependent weights, which are added as a regularization term to the cost function. Additionally, multi-scale details of the image are added to the model through another regularization term that involves projection onto PCA basis, which is constructed using similar patches extracted across different scales of the input image.

Learning-based Blur Detection and Segmentation from a Single Image

IIT

Madras

Designed a two-level architecture for blur-based segmentation of a single image. First network is a fully convolutional encoder-decoder for estimating a semantically meaningful blur map from the full-resolution blurred image. Second network is a CNN-based classifier for obtaining local (patch-level) blur-probabilities. Fusion of the two network outputs enables accurate blur-segmentation using Graph-cut optimization over the obtained probabilities.

Recovering sharp image and scene geometry from a single motion blurred image

IIT Madras

Designed an algorithm for recovering the latent image, planar geometry and camera motion from a single motion blurred image. Proposed a method to estimate planar surface orientation from blur kernels obtained from various location in an image. These estimates are fed

into an alternative optimization based framework to jointly estimate the sharp image and plane-segmentation map.

Depth-based Segmentation and Camera Trajectory Estimation from a Blurred Image for Forgery Detection *IIT Madras*

This work proposes an efficient algorithm for depth based segmentation using spatially-distributed blur-kernels present in a single motion-blurred image of a 3D scene. The segmentation is then further utilized to estimate global camera motion from a single blurred image of a 3D scene. Finally, local blur profiles are compared with the global motion model to highlight inconsistencies and detect spliced regions.

Multi-level Weighted Enhancement for Underwater Image Dehazing *IIT Madras*

Attenuation and scattering of light are responsible for haziness in images of underwater scenes. We propose an approach to reduce this effect, based on the underlying principle is that enhancement at different levels of detail can undo the degradation caused by underwater haze. The depth information is captured implicitly while going through different levels of details due to depth-variant nature of haze. Hence, we judiciously assign weights to different levels of image details and reveal that their linear combination along with the coarsest information can successfully restore the image. Results demonstrate the efficacy of our approach as compared to state-of-the-art underwater dehazing methods.

Large-Area Mosaic Construction and Restoration of Deep Underwater Imagery *National Institute of Ocean Technology, India - IIT Madras*

This work deals with the problem of mosaicing deep underwater images (captured by Remotely Operated Vehicles), which suffer from haze, color-cast, and non-uniform illumination. We propose a framework that restores these images in accordance with a suitably derived degradation model. Furthermore, our scheme harnesses the scene-depth information present in the haze for non-rigid registration of the images before blending to construct a mosaic that is free from artifacts such as local blurring, ghosting, and visible seams.

Denoising and enhancement of SEM images *KLA-Tencor - IIT Madras*

Noise is very common in scanning electron microscope (SEM) images acquired with slow scanning and have a direct impact on further processing and defect detection. Analyzed the noise problems and developed a denoising approach based on region-of-interest segmentation and multi-level enhancement.

3D Surface Estimation using Multi-channel SEM *KLA-Tencor - IIT Madras*

Developed a photometric stereo based algorithm for 3D surface reconstruction of semiconductor wafers captured using a multi-channel SEM. Incorporated domain-specific priors based on surface and sensor patterns in the optimization framework for robust estimation of the 3D surface structures.

**SCHOLASTIC
ACHIEVEMENTS**

- My team was a finalist in all three tracks of the **Super-resolution Challenge** :Perceptual Image Restoration and Manipulation (PIRM) of ECCV 2018.
- Our work was selected for the **Best Paper Award** (Runner Up) at the Indian Conference on Computer Vision, Graphics and Image Processing (ICVGIP) 2018.
- Received travel grant from IIT Madras to present my work in the International Conference on Image Processing (ICIP) 2016, Arizona, USA.
- **Top 0.3%** in Graduate Aptitude Test in Engineering (GATE) 2016 (Nationwide post-graduate entrance exam of Indian Engineering Universities, very competitive with nearly 150,000 participants.)
- **Scholarship** for under-graduate studies offered by Government of India, Ministry of Human Resource Development (2009-2011).
- **Top 1%** in Indian Institute of Technology- Joint Entrance Examination (IIT-JEE)

2009 (Nationwide entrance exam for IITs, very competitive with nearly 400,000 participants.)

PROFESSIONAL SERVICES **Reviewer** for the following conferences:

- Indian Conference on Computer Vision, Graphics and Image Processing (ICVGIP) 2018
- International Conference on Signal Processing and Communications (SPCOM) 2018.
- National Conference on Computer Vision, Pattern Recognition, Image Processing and Graphics (NCVPRIPG) 2017
- International Conference on Advances in Pattern Recognition (ICAPR) 2017
- National Conference on Communications (NCC) 2017.

RELEVANT COURSEWORK

- Image Signal Processing
- Digital Video Processing
- Digital Signal Processing
- Applied Linear Algebra
- Deep Learning
- Machine Learning for Computer Vision
- Fundamentals of Linear Optimization
- Probability Foundations

TEACHING EXPERIENCE

Assisted in deciding course contents, conducting lectures and evaluating tutorials and programming assignments for the following courses:

- *Deep Learning for Imaging* under Prof. A.N. Rajagopalan and Dr. Kaushik Mitra
- *Image Signal Processing* under Prof. A.N. Rajagopalan
- *Introduction to Electrical Engineering* under Prof. A.N. Rajagopalan

CONFERENCES AND WORKSHOPS ATTENDED

Conferences:

- **ICIP** 2016, **ICVGIP** 2016, **NCC** 2016, **ICVGIP** 2014.

Workshops:

- "Workshop on Computational Brain Research" by Center for Computational Brain Research (CCBR), IIT Madras (2018).
- "Summer School on Deep Learning for Computer Vision " organized by CVIT, IIIT Hyderabad (2017).
- "Human Computer Interface" organized by Dr. Pradipta Biswas at IIT Mandi (2012).
- "Swarm Robotics" organized by Robosoft Systems Inc., IIT Bombay (2010).

SKILLS

Programming: Python, MATLAB, Latex, C/C++ (familiar), Lua (familiar)
Libraries: PyTorch ,Tensorflow, Torch, MatConvNet, OpenCV

REFERENCES

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